INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 3, No. 7, p. 114-118, 2013

RESEARCH PAPER OPEN ACCESS

Physiochemical variations in soil and behavioral changes in growth pattern of lentil in response to application of fertilizer factory effluent

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Key words: Lentil, *Lens culinaris,* industrial effluent, germination behavior.

doi: http://dx.doi.org/10.12692/ijb/3.7.114-118 Article published on July 25, 2013

Abstract

Owing to its economic aspect, the trend of using industrial effluent to irrigate agricultural crops is gaining popularity in Pakistan. This study was carried out to gauge the possible effects of fertilizer factory effluent on the chemical properties of soil and growth performance of lentil (*lens culinaris*) crop. Four different concentrations of fertilizer factory effluent (25%, 50%, 75% and 100% concentrations) were used as treatments along with control (tap water) to treat lentil seeds in plastic bags. Germination behavior of lentil was studied using different germination indices and growth performance was evaluated by measuring physical growth parameters. Results concluded that germination behavior was negatively affected at higher concentration of industrial effluent whereas root and shoot length and seedling biomass also had decreased significantly when grown at maximum concentration of industrial effluent. There was however an increase in the seedling length and seedling biomass when grown at 50% of the effluent concentration showing the beneficial range of industrial wastewater concentration for growing lentil crop. Moreover, the analysis of soil samples revealed that pH, E.C and organic matter content of soil were significantly higher when treated with fully concentrated industrial effluent.

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Introduction

Although the use of industrial effluent for irrigating agricultural crops has been considered an economical source of irrigation water, still the use of industrial wastewater has been a debatable issue owing to the fact that certain crops have been reported to have responded negatively to the application of industrial effluent (Sutton *et al.*, 1978). Many a studies have advocated the case that different agricultural crops tend to accumulate the toxic metals present in the factory effluent which in turn not only reduces the overall yield of the crop but also poses threat to the livestock and human population feeding on the final crop product (Asim *et al.,* 2013).

In most of the developing countries including Pakistan, the use of industrial effluent for growing field crops is quite a common practice (Manzoor *et al.,* 2013). This increasing practice is threatening the health and yield of crops in the long run. Farmers assume fertilizer factory wastewater a potential source of adding useful salts to their field crops. However many researchers (Ozoh and Oladimeji, 1984; Rahman *et al.* 2002; Street *et al.* 2007) have reported that such an irrational use of wastewater is not only affecting the micro-environment and health of field crops but is interfering with soil's natural potential to support vegetation as well.

Since only a handful of research studies have been carried out to investigate the effect of various industrial effluents on the soil's physiochemical properties and growth performance of major agricultural crops in tropical Arid areas of Pakistan, this study was planned taking lentil as the subject crop since lentil is widely grown under fertilizer factory effluent in this part of the world.

Materials and methods

Seed materials

The certified seeds of *Lens culinaris* were procured from Agricultural Research Farm, Bahauddin Zakariya University Multan. Seeds with uniform size, color and weight were chosen for the experimental purpose.

Collection of fertilizer factory effluent

The effluent samples were collected in plastic container from the point of disposal from a fertilizer factory located in Multan District and stored in cold room until analysis for physicochemical parameters such as temperature, color, pH, biological oxygen demand (BOD), total solids (TS), total suspended solids (TSS), total dissolved solids (TDS) and presence of heavy metals in it.

Pot culture experiment

The experiment was conducted in the laboratory, Department of Forestry and Range Management, Bahauddin Zakariya University Multan, at room temperature (25 C^{o}). The possible effects of fertilizer factory effluent on the seed germination and growth performance of lentil were investigated by sowing the lentil seeds in plastic pots containing well drained loamy soil with ratio of sand silt and clay as 1:1:1. Four different concentrations (viz., 25%, 50%, 75%, and 100%) of fertilizer factory effluent were prepared along with a control (tap water). Pre-sterilized with 0.1% mercuric chloride, seven seeds were sown in each plastic pot. All treatment pots were supplied with 400 ml of respective effluent concentration on daily basis. Soon after 10 days of germination, seedlings were thinned to three per pot. The experiment was laid down as completely randomized design with five replication of each treatment including control.

Germination parameters

The germinated seeds were counted regularly after 24 hours interval following the standard procedure (AOSA, 1990). A seed was considered germinated when its radical had become 2 mm in size. The final germination percentage was calculated fourteen days after sowing seeds. Parameters like Final Germination Percentage, Germination Energy, Germination Index, Relative Germination Rate, Mean Germination Time, Days Required For 50% Germination of Total Seeds, Days Required For 50% of Total Germinated Seeds, Speed of Accumulated Germination, Speed of Germination, Coefficient of The Rate of Germination, Germination Value, Percent

Inhibition, Peak Value and Delay Index, Germination Distribution, and Corrected Germination Index were determined using formulas as mentioned by (Manzoor *et al.,* 2013).

Seedling growth parameters

Data were recorded on root fresh weight, shoot fresh weight, root dry weight, shoot dry weight, root length, shoot length, number of leaves and branches at the end of the experiment (4 weeks) according to the standard techniques.

Physiochemical analysis of soil

Soil samples from each treatment pots were analyzed for such physiochemical parameters like E.C, pH, Saturation percentage following the standard methods.

Statistical analysis

The data were pooled and analyzed using MSTAT-C Program (MSTAT Development Team, 1989). LSD test at 5% level of probability was used to test the differences among mean values (Steel *et al.,* 1997).

Results and discussion

Analysis of the fertilizer factory effluent shows that it has yellowish color with characteristics ammonia smell in it. The average temperature of effluent in winters was 27C°. Values for pH and E.C were recorded as 7.8 and 9.5 respectively. Values for dissolved solids, suspended solids, BOD, COD and total nitrogen were recorded as 385 mg/L, 171 mg/L, 2.1 mg/L, 34 mg/L, 321 mg/L and 58 mg/L respectively. Moreover, higher levels of cadmium and magnesium were also found in the industrial effluent sample (0.17 mg/L and 62 mg/L respectively).

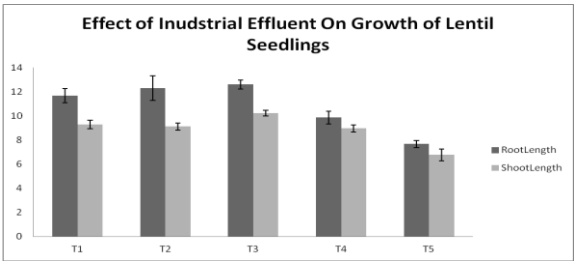

Fig. 1. T^1= Tap Water, T^2= 25% Effluent Conc. , T^3= 50% Effluent Conc, T^4=75% Effluent Conc. , T^5=100% Effluent Conc.

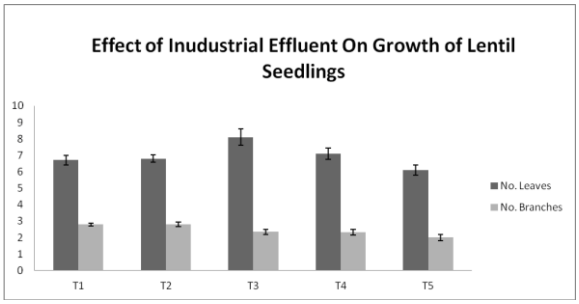

Fig. 2. T^1= Tap Water, T^2= 25% Effluent Conc. , T^3= 50% Effluent Conc, T^4=75% Effluent Conc. , T^5=100% Effluent Conc.

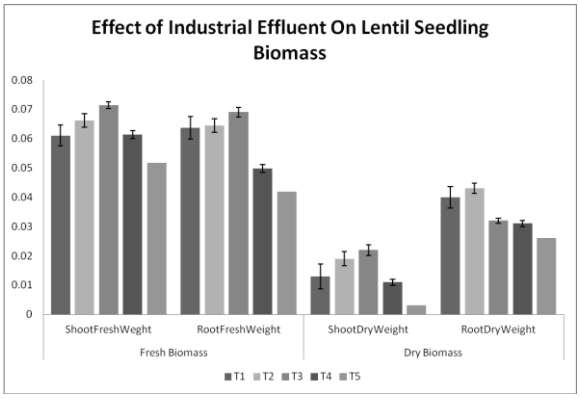

Fig. 3. T^1= Tap Water, T^2= 25% Effluent Conc. , T^3= 50% Effluent Conc, T^4=75% Effluent Conc. , T^5=100% Effluent Conc.

Results for length and biomass of lentil seedlings showed difference when treated with different concentration of fertilizer factor effluent. As clear from Figure 1, at lower concentration the root and shoot length of lentil seedlings were higher than that of control. This range of wastewater concentration can be taken as beneficial range for lentil crop whereas at higher concentration of the same wastewater, a declining trend was seen which indicates the toxicity fertilizer factory effluent to lentil. A similar trend was seen for number of leaves and number of branches for different treatment means (shown in Figure 2). Similar results were seen in fresh and dry biomass of the roots and shoot of lentil seedlings where higher concentration of effluent simply acted as inhibitor of root and shoot growth while at mild concentrations, the seedlings performed better than that of control (Figure 3). These results have been in accordance with the findings of Kaushik *et al.* (2004) where similar results were reported for

toxic effects of higher concentrations of sugar factory effluent on the growth performance of wheat seedlings. In our study, the negative germination behavior and decrease in the length and biomass of lentil seedlings at higher concentration of fertilizer factory effluent was attributed to the presence of more than permissible amounts of cadmium and magnesium in the wastewater which actually caused higher osmotic pressure leading to the suppression of seed germination and wilting of seedlings (Gomathi and Oblisami 1992). The excessive amounts of chlorides and high alkalinity of the industrial effluent also contributed to these results (shown in Figure 4 & Figure 5).

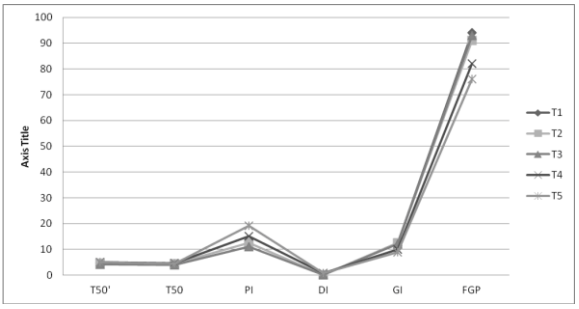

Fig. 4. Effect of Industrial Effluent on Germination Behavior of Lentil.

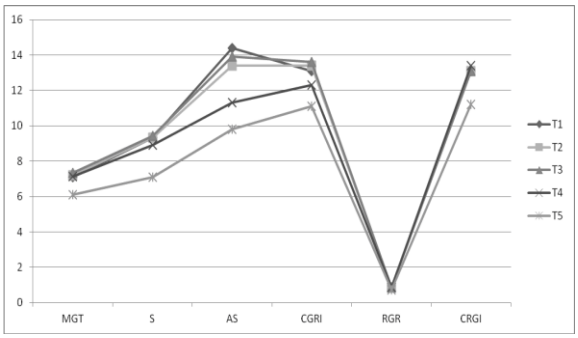

Fig. 5. Effect of Industrial Effluent on Germination Behavior of Lentil.

T_1 = Treatment 1, *T_2= Treatment 2, *T_3=Treatment 3, *T_4=Treatment 4, *T_5= Treatment 5

*T50'= Days Required for 50% Germination of total germinated seeds ,*T50= Days Required for 50% Germination of total seeds ,*PI=Percentage Inhibition ,*DI= Delay Index ,*GI= Germination Index,*FGP= Final Germination Percentage ,*MGT= Mean Germination Percentage,*S= Speed of Germination,*AS= Accumulated Speed of Germination , *CGRI= Corrected Germination Rate Index ,*RGR= Relative Germination Rate, CRG=Coefficient of Rate of Germination

Change in pH and E.C of the soil seemed to be strongly correlated with the increase in concentration of industrial effluent (Figure 6). Both these parameters increased with the increasing concentration of industrial wastewater. In fact, many scientists have reported changes in the physiochemical properties of soil due to application industrial effluent. Mitra and Gupta (1999) reported that such an increase in the pH and E.C is due to the increasing concentration of different salts in the fertilizer factory effluent. Moreover, an increase in E.C of soil at higher concentration may be due to the higher E.C value of effluent itself. Similar results were reported by Rusan *et al.* (2007) and Jahantigh (2008). Increase of organic matter content with increasing concentration of industrial effluent can be attributed to higher levels of nitrogen in fertilizer factory effluent (Rusan *et al.,* 2007). Similar results were recorded by Rattan *et al.* (2006) when the researchers treated soil with industrial wastewater. Debosz *et al.* (2002) also concluded that consistent application of industrial effluent can lead to increase in organic matter content of the soil.

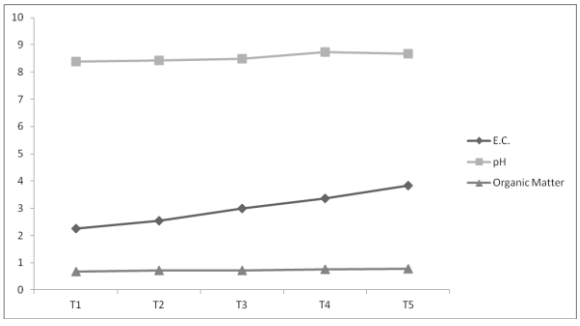

Fig. 6. Effect of Industrial Effluent On E.C, pH and Organic Matter content of soil.

Acknowledgement

Authors would like to express deepest gratitude to the laboratory staff of department of Forestry, Range and Wildlife Management, FAST, Bahauddin Zakariya

University Multan for their technical assistance during this study.

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